U.S. Department
of Transportation

Federal Aviation Administration

Office of Aviation Policy and Plans

Washington, D.C. 20591

Establishment Criteria For Airport Surface Detection Equipment (ASDE) III

Accesion For		
NTIS CRA&I	X	
DTIC TAB	☐	
Unannounced	☐	
Justification per form 50		
By		
Distribution /		
Availability Codes		
Dist	Avail and / or Special	
A-1		

DISTRIBUTION STATEMENT A

Approved for public release;
Distribution Unlimited

FAA-APO-93-12

1993

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
APO-93-12		

4. Title and Subtitle Establishment Criteria Airport Surface Detection Equipment (ASDE)	5. Report Date
	6. Performing Organization Code FAA-APO
7. Author(s) Lawrence Barry, Stefan Hoffer, Earl Bomberger, Frank Berardino	8. Performing Organization Report No.
9. Performing Organization Name and Address Office of Aviation Policy, Plans, and Management Analysis Federal Aviation Administration 800 Independence Avenue, SW Washington, DC 20591	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address Office of Aviation Policy, Plans, and Management Analysis Federal Aviation Administration 800 Independence Avenue, SW Washington, DC 20591	13. Type of Report and Period Covered Establishment Criteria
	14. Sponsoring Agency Code FAA-APO

15. Supplementary Notes

16. Abstract

This report presents the criteria and computation methods to be used in determining eligibility of terminal locations for the establishment of Airport Surface Detection Equipment (ASDE) based on an economic analysis of the costs and benefits of this equipment. The criteria compare the present value of ASDE benefits at a site with the present value of ASDE costs over a 20-year time frame. A location is eligible for ASDE establishment when the benefits which derive from operating the equipment exceed the installation and operation costs--the Benefit/Cost ratio is greater than or equal to one. An ASDE meets discontinuance criteria when the costs of continued operation exceed the benefits--the Benefit/Cost ratio is less than one.

The criteria have been revised from those published in December 1975, to include improved benefit algorithms, incorporate up-to-date methods of analysis, and adjust for changes in the aviation environment since 1975. Distinctions based on aircraft size are also eliminated. In addition, ASDE costs, accident rates and benefit unit values--including values of statistical lives saved, injuries avoided, property damage, and passenger and aircraft time saved--have been updated to incorporate the most recent data.

Based on projections of current future aviation activity, the new criteria, when applied, suggest those sites that should be considered candidates for ASDEs. When compared to the results at the time 1975 criteria were published, more sites now qualify for ASDEs. The present criteria also show more airports qualify than the 1975 criteria predicted for 1985. All sites qualifying under the 1975 criteria also qualify under the new criteria.

17. Key Words	18. Distribution Statement
ASDE, Benefit vs Cost Radar, Airport Surface Traffic, Tower Controller	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	64	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

EXECUTIVE SUMMARY

This report presents the criteria and computation methods to be used in determining eligibility of terminal locations for the establishment of Airport Surface Detection Equipment (ASDE) based on an economic analysis of the costs and benefits of this equipment. The criteria compare the present value of ASDE benefits at a site with the present value of ASDE costs over a twenty-year time frame. A location is eligible for ASDE establishment when the benefits which derive from operating the equipment exceed the installation and operation costs--the Benefit/Cost ratio is greater than or equal to one. An ASDE meets discontinuance criteria when the costs of continued operation exceed the benefits--the Benefit/Cost ratio is less than one.

Site-specific activity forecasts are used to estimate two categories of ASDE benefits:

- o Benefits from prevented aircraft accidents;
- o Benefits from increased efficiency of aircraft operations

Explicit dollar values are assigned to the prevention of fatalities, injuries, property damage and time saved. ASDE establishment costs include:

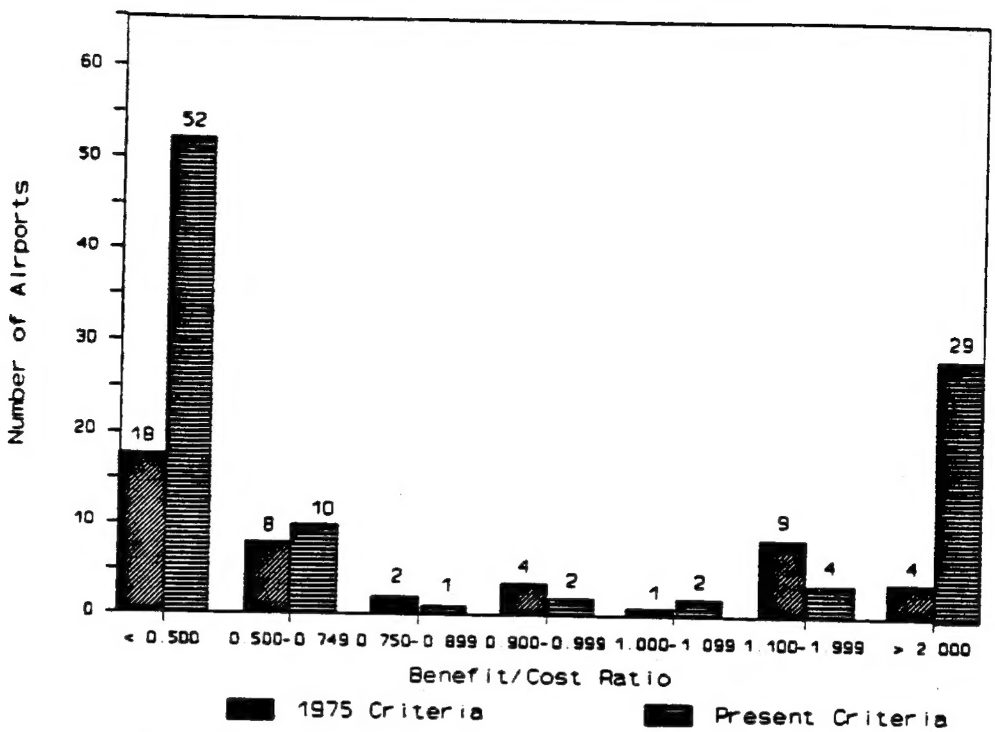
- o Annual operating costs, including support, maintenance, and the cost of electricity;
- o Investment costs: facilities, equipment and site preparation.

The criteria have been revised from those published in December, 1975, to include improved benefit algorithms, incorporate up-to-date methods of analysis, and adjust for changes in the aviation environment since 1975. Distinctions based on aircraft size per se are also eliminated. In addition, ASDE costs, accident rates and benefit unit values--including value of statistical lives saved, injuries avoided, property damage, and passenger and aircraft time saved--have been updated to incorporate the most recent data.

Based on projections of current and future aviation activity, the new criteria suggest that a total of 35 civil airport sites should be considered candidates for ASDE with the Airport Movement Area Safety System (AMASS) enhancement. An additional 3 civil airport sites are candidates for ASDE without AMASS. When compared to the results at the time the 1975 criteria were published, more sites now qualify for ASDEs. The present criteria also show more airports qualifying than the 1975 criteria predicted for 1985. All sites qualifying under the 1975 criteria also qualify under the new criteria. A comparison of the results of the two studies for airports included in both is contained in Figure ES.1.

These criteria, as well as other criteria used in determining eligibility of terminal locations for establishment, discontinuance and improvements of their equipment and services are summarized in FAA Order 7031.2C, Airway Planning Standard No. 1, Terminal Air Navigation Facilities and Air Traffic Control Services (APS-1).

Figure ES.1: Benefit/Cost Ratios from Present and 1975 Studies



I. INTRODUCTION

Effective management of Federal Airport and Airway resources requires directing funds to projects for maximum benefits derived from proposed capital investments. FAA develops criteria with which it can assess installation and operation of facilities and equipment at potential sites. For inexpensive equipment, the criteria may be simple traffic activity thresholds. For example, an airport with 50,000 itinerant operations per year qualifies for an ATIS (Automatic Terminal Information Service). Evaluation of larger, more expensive facilities, such as Airport Surface Detection Equipment (ASDE), are based on economic analysis of benefits and costs.

This report presents the methods and values for conducting economic analysis of costs and benefits of ASDE.[1] It also summarizes results of an application of these methods to 100 airports in the United States based upon site-specific activity, weather and other data. The initial establishment criteria for ASDE were developed in 1975. They identified qualifying sites based on the present values of benefits and costs. In the case of the initial establishment criteria, qualifying sites could be closely approximated by whether an airport had a Category III runway, or 180,000 or more annual itinerant operations of which 100,000 were by certificated route air carriers.

A. Kinds of Benefits and Costs

ASDEs generally provide three kinds of direct benefits to aircraft operations and passengers, and create two kinds of costs:

Benefits:

- Safety benefits occur at ASDE-equipped airports; controllers are better positioned to identify when aircraft have exited active runways, and if aircraft have entered incorrect active runways or taxiways during times of reduced light and visibility.
- Aircraft operating costs are reduced and passengers' time is saved when departure delays are reduced during times of reduced light or visibility.
- Other non-quantifiable benefits may be associated with ASDE. Aircraft operating costs and passengers' time may be saved when aircraft are able to taxi between runways and terminals more expeditiously, for example.

---

[1] A more general discussion of benefit/cost analysis may be found in FAA-APO: "Economic Analysis of Investment and Regulatory Decisions-A Guide," January, 1982.

Costs:

- o ASDE investment costs include the capital expenditure on ASDE equipment, construction, and the site improvements required to accommodate it.

- o ASDE operations and maintenance costs include electricity, support, and maintenance.

B. Unit Economic Values and Activity Measures

ASDE benefit estimates are prepared by assigning dollar values to prevented fatalities and injuries and to passenger and aircraft time savings. Unit economic values for these as well as aircraft repair, replacement and operating costs are the "economic values" used in FAA Benefit/Cost studies.[2] Estimates were made in FY 1990 base-year dollars.

ASDE efficiency benefits are estimated for specific airports and depend upon the diurnal pattern of aircraft operations throughout the day. The best source which identifies the pattern is the "Official Airline Guide" (OAG) which provides information on the number of scheduled commercial service operations (SCS) at each of the air carrier airports in the United States. However, these data do not cover non-scheduled commercial service, or non-commercial traffic. Data on these operations are available on an annual basis from the "Terminal Area Forecast";[3] the annual totals are projected onto the diurnal patterns contained in the "General Aviation Pilot and Aircraft Activity Survey."[4] Combining these data with OAG flight schedules yields estimates of total operations demand at each airport for each operating hour of the day.

ASDE efficiency benefits are estimated through the application of a queuing model; this model calculates the reduction in aircraft delay times at each airport for each hour of the day occasioned by the presence of an ASDE. The reductions in delay depend on the characterization of airport capacity, the configuration of runways, the placement of the airport tower, and local weather and visibility conditions; all of these factors are taken into account using site-specific information.

It should be noted that the benefits and costs of ASDE must be evaluated over the 20-year life of the equipment. Aviation activity will vary over the time period; however, the capabilities of the airports will also change over time as improvements in other facilities and equipment are put into place. Because ASDE efficiency benefits must be evaluated on an hour-by-hour basis, it is difficult to project how the interactions between future increased demand and increased capability will net out in

---

[2] FAA: "Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs," FAA-APO-90-10 (1990) and DOT guidance letter of June 22, 1990.

[3] FAA-APO: "Terminal Area Forecasts," (1992)

[4] FAA: "General Aviation Pilot and Aircraft Activity Survey," (1987), Tables 24 and 25.

terms of service times per aircraft. However, in general, airport capacity will expand to meet increased demand; in the present analysis, the rate of expansion is assumed to be equal to the rate of increase in demand.[5]

Safety benefits depend upon the projected rate of ASDE-preventable accidents and upon the projected number of operations at each facility. ASDE-preventable accidents are defined as those accidents which have happened in the past that would have had a high likelihood of being avoided had an ASDE been available to operate in conditions of reduced visibility or darkness. Dividing these accidents by exposure (operations taking place during times an ASDE would be operating) yields a rate of ASDE-preventable accidents. Multiplying this rate by operations at specific airports (adjusted for the exposure to ASDE-relevant visibility and light conditions) yields an estimate of expected annual ASDE-preventable accidents. Annual ASDE safety benefits are based on valuations of these expected accidents.[6]

C. How Criteria Are Applied

Establishment criteria are used to evaluate investments at particular locations prior to facilities and equipment budget submissions, or reprogramming. Meeting the economic criteria usually is a necessary condition for including a site in the budget. When the number of qualifying sites is larger than overall budget constraints will allow, some sites may not be funded, even if economically justified. The converse is also true; locations may be excepted from meeting the economic criteria because of other factors such as particular site-specific characteristics not adequately captured by the benefit/cost algorithms.

Installations may be discontinued if the benefits fall below annual operations and maintenance costs, adjusted for any one-time shutdown cost. This can happen if activity levels drop, or if reanalysis of benefits suggests that investments do not provide the same degree of benefits as previously believed.

D. Relationship of ASDE to Other FAA Projects

In addition to ASDE, there are two additional projects in FAA's "Capital Improvement Plan" (CIP), December 1990, which build upon ASDE to improve airport surface safety and/or efficiency:

- Airport Movement Area Safety System (AMASS) will display enhancements to ASDE and provide audible alerts to controllers in the tower cab further enhancing the ability

---

[5] If the rate of increase in demand exceeds (is less than) the rate of capacity expansion, delay benefits estimated in the ASDE efficiency model will be understated (overstated).

[6] Using FAA "Economic Values," FAA-APO-90-10, op. cit.

of ASDE to prevent runway incursions. Currently in the R,E, & D pipeline (a Research and Design contract was awarded[7]), AMASS is expected to be implemented in a relatively short time with first implementation in 1994.[8]

The analysis supporting these establishment criteria is based on ASDE with AMASS enhancement[9]. In the analysis, ASDE and AMASS are considered to share the same set of safety benefits. There is good reason, however, to believe that AMASS, when implemented, will provide significant safety benefits beyond those shared with ASDE. For example, these criteria consider safety benefits which accrue only during the hours of darkness or during poor visibility resulting from weather conditions. AMASS will also provide safety benefits during daylight and good visibility. These benefits when added to those estimated in this analysis will qualify additional ASDE/AMASS units in excess of those qualified by considering only shared benefits. Accordingly, prior to implementation of AMASS, these criteria should be amended to reflect such benefits. AMASS costs should also be updated prior to AMASS implementation based on program development experience.

o Airport Surface Traffic Automation (ASTA), a three phased project, which will provide runway status light and data tag enhancements on ASDE, taxi route compliance monitoring, traffic management aids, airport configuration management aids, surface traffic data in cockpit , direct cockpit alerts, active taxi route guidance, coordination with other capacity improvement projects, such as Enhanced Traffic Management System and Terminal Air Traffic Control Automation, unloading ground channel, data link services, and flight route clearance delivery. There is reason to believe that ASTA will provide significant efficiency benefits, not provided by ASDE; in particular, ASTA will be effective during daylight hours, a period during which no ASDE benefits are estimated.

ASTA is a much more sophisticated, expensive, and broadly scoped program than AMASS. It also is far less well defined at this time. It is currently in the advance planning and engineering phase where alternatives are being considered and requirements are being established, reviewed, and validated; implementation will not

---

[7] FAA: "Capital Investment Plan, First Draft" (April 17, 1992), p. 6-2-4.

[8] Ibid., p. 6-2-4.

[9] In this study benefits for ASDE (with AMASS): (a) are estimated only for periods of darkness and for periods of bad weather, (b) include only those benefits which ASDE is anticipated to provide (no benefits which AMASS might provide were estimated), and (c) encompass no benefits for using ASDE to process traffic in VFR conditions to increase capacity---if and when such an operational concept is developed and implemented, additional benefits to ASDE and AMASS may accrue.

be complete until sometime in the first decade of the next century.[10] For this reason, the criteria do not encompass ASTA.

E. Changes from Previous Criteria

This report, and the change to Airway Planning Standard No. 1 that will result from it, establishes a methodology for implementing the new criteria. This methodology supersedes FAA Report APS-75-3: "Establishment Criteria for ASDE-3."[11]

Both the new and old criteria provide estimates of efficiency benefits on an airport-specific basis. However, the new criteria employ data that are more specific to the conditions and type of operations occurring at the individual airports evaluated. These differences in specificity are enumerated in Table 1.1, and discussed in more detail below.

It should also be noted that the cost of ASDE has changed significantly since the old criteria were published. The old criteria were based on Government cost estimates made before the production contract was awarded. The new criteria reflect actual experience with production of ASDE units and are based on contract data and Government estimates involving the cost of a project which has already installed its first unit and which is currently undergoing operational testing.

Airport Processing Time

Central to the improvement in efficiency are estimates of the reductions in time required to process departing aircraft during times of poor visibility and/or darkness. In the new criteria, processing time estimates are based upon a series of field trials conducted during different visibility and light conditions; these field results provided the data necessary to estimate processing time. In the old criteria, processing times were estimated without the benefit of field trials.

Incidence of Bad Visibility

In the present establishment criteria, five years of data from weather records for individual airports maintained by the National Atmospheric and Oceanographic Administration (NOAA) were employed to identify the percentage of time poor visibility conditions existed for each hour of the day. These percentages are good estimators of the probability of poor visibility conditions for each hour of the day at each specific airport site. In the 1975 establishment criteria for ASDE, national averages for poor visibility were applied to all airports.

---

[10] Ibid., p. 6-2-5.5.

[11] FAA: "Establishment Criteria for ASDE-3", (December, 1975).

Conditions When ASDE Is Effective

In the new criteria, an ASDE was considered to be effective during non-daylight hours or during periods of weather when visibility conditions were such that a controller in an airport tower could not see all portions of the runway surfaces being employed at that time. This situation depends not only upon the visibility conditions provided by the NOAA data, but also on the runway configuration of each airport, and the location of the tower. The criteria take into account both the runways likely to be in use, and their distance from the tower to determine whether an ASDE would be necessary during that particular hour of the day. In contrast, the 1975 criteria assumed that ASDE would be effective during all instrument meteorological conditions (IMC).

Table 1.1: Key Differences In Evaluating Benefits Between Old and New Criteria

Efficiency Benefits	Old Criteria	New Criteria
1. Airport Processing Time	FAA Standards	Observed in Field Trials
2. Incidence of Bad Visibility	National Average	Site-specific based on NOAA data
3. Conditions When ASDE Effective	Based on Category of Weather Conditions	Based on visibility conditions and distance a controller must see at a specific site
4. Runway Configuration	Typical of U.S. Airports	Site-specific based on a survey of tower chiefs
5. Delay Estimates	Based on Average Hourly Operations	Based on actual diurnal pattern of operations
6. Passenger Time Savings	Excluded	Included
Safety Benefits	Based on limited accident experience at a single airport	Included based on evaluation of all ASDE-preventable accidents in United States

Runway Configurations

The amount of time saved attributable to ASDE depends upon the number of runways being used during specific times of the day and during specific visibility conditions. Obviously, the more runways capable of processing departures, the shorter will be the delays experienced by aircraft operators, all other things being the same. The new establishment criteria take into account the actual runway configurations likely to be employed during specific weather conditions. This information was developed from the "Tower Chief Survey" conducted for this study and discussed in detail in Appendix C. In the 1975 criteria, typical runway configurations were applied to all airports without reference to actual airport conditions.

Delay Estimates

The delays likely to be prevented by the installation of ASDE depend upon the amount of aircraft traffic during specific times of the day. At major airports, traffic patterns tend to peak during specific times. For example, most airports show substantial departure activity both early in the morning, and late in the afternoon; during other periods of time, aircraft operations may be substantially lower. In the present establishment criteria, this diurnal pattern of aircraft operations is specifically taken into account based primarily upon the actual operations of air carriers at each airport (as described in the "Official Airline Guide"). The model also takes into account typical patterns of other aircraft operations.[12] As a result, the efficiency model shows that ASDEs provide important reductions in delay during peak demand periods of time when light and visibility conditions are poor, but provide little benefits during times of the day when there are few aircraft operations. In contrast, the 1975 establishment criteria based benefit estimates on average hourly operations; such estimates may have significantly overstated or understated delay benefits at specific airports.

Passenger Time Savings

Passengers are likely to benefit directly from the installation of ASDE because the reduced delay times they will experience in waiting to depart. These passenger time savings are identified for each hour of the day based upon specific delay conditions estimated for each airport. In contrast, in the previous establishment criteria, no account of passenger time savings was made.

Safety Benefits

ASDEs have important safety benefits. They permit controllers to see activity on runways in use as well as on taxiways even during periods of poor light or visibility. In the absence of ASDEs, controllers must rely on position reports made by aircraft, and other vehicles on the runway surface. Not only do these position reports slow the processing time at the airport, but there is a danger that

[12] FAA: "General Aviation Pilot and Aircraft Activity Survey," op. cit.

controllers or those operating aircraft and vehicles may become confused. Such confusion can erode safety performance. In the new establishment criteria, ASDEs make a contribution to safety performance by reducing the likelihood of accidents on the runway surface. These accidents may take place during landing or departure phases of flight, or during taxiing. A complete review of domestic (i.e., occurring within the United States) airline accidents for the period of 1971 through 1991 was conducted to identify these types of accidents. The resulting accident rates were applied to all groups of users for the new establishment criteria. In the previous establishment criteria, safety benefits were estimated based on the limited information available on ASDE-preventable accidents that occurred at Chicago O'Hare Airport.

Planned Future Improvements

Due to the difficulty in its modelling, one important potential benefit was not included in the 1975 criteria and is not in this criteria either. It is the assistance which ASDE-3 can provide to a controller in moving aircraft across intersecting runways under conditions of low visibility or bad weather. This capability would enable a controller to decrease the time between an aircraft leaving the gate and when it arrives at the tail of the queue of aircraft awaiting departure. More importantly, this capability would provide economic benefits to an arriving aircraft and its passengers--the aircraft could be moved from the landing runway to the gate more efficiently, thus saving time and fuel. It is planned to incorporate modelling to capture this benefit when funding becomes available. It should be noted, however, that those airports which qualify for ASDE-3 without this improvement in modelling will still qualify for ASDE-3 when the improvement is implemented. This improvement may enable additional airports to qualify and may affect the specific ranking of those airports which qualify relative to other qualifying airports.

Summary of Current Results and Projections for Year 2000

As a consequence of these differences between the establishment criteria developed in 1975, and those presently being discussed, 21[13] additional sites are currently eligible for ASDE installation based on benefit/cost criteria further discussed below. In addition, all sites identified as being eligible in the 1975 criteria remain eligible under the new criteria.

Figure 1 summarizes the results of the current study and results based on expectations for a projection made for the year 2000. From the standpoint of 1992, 35 civil airports are eligible for an

[13] In 1975, 14 civil sites qualified for 16 units of ASDE (2 of these sites required 2 ASDE units). In the new criteria, 35 civil sites qualify for 38 units of ASDE with AMASS enhancement (3 of these sites require 2 ASDE) and an additional 3 units will be deployed to Andrews Air Force Base, the FAA Academy, and the FAA Technical Center. Three additional sites qualify for the ASDE without AMASS enhancement. (When an assessment of AMASS provided benefits is made in the future, it is anticipated that additional sites beyond the 35 may qualify for ASDE with AMASS enhancement.)

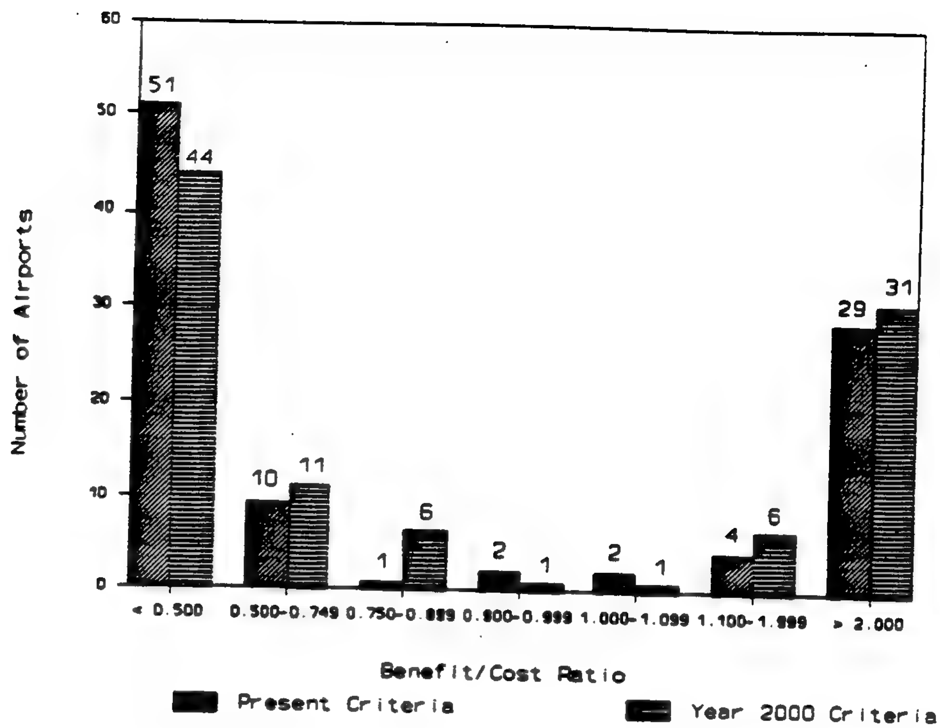
ASDE because the benefit/cost ratios exceed 1.0. Projecting forward to the year 2000 (in base-year 1990 dollars) 38 civil airports would qualify for an ASDE.[14]

F. Organization of this Report

Benefit/cost criteria are presented in Chapter II. Details for the cost calculations are contained in Chapter III. The efficiency benefit estimation methodology is reported in Chapter IV and Appendix A and Appendix C; the same chapter and Appendix B discuss safety benefits. The results of applying the criteria are presented in Chapter V.

[14] In 2000, 38 sites will qualify for ASDE with AMASS enhancement under current assumptions of traffic growth specific to each of the 100 largest airports. One additonal site qualifies for the ASDE without AMASS enhancement. (When an assessment of AMASS provided benefits is made in the future, it is anticipated that additional sites may qualify for ASDE with AMASS enhancement.)

Figure 1: Comparison of Benefit/Cost Ratios for Current Study Projected to the Year 2000



II. AIRPORT SURFACE DETECTION EQUIPMENT (ASDE) CRITERIA

This chapter summarizes the revised establishment and discontinuance criteria developed in this report for ASDE. The criteria will be effected through a change to FAA Order 7031.2C, "Airway Planning Standard Number One, Terminal Air Navigation Facilities and Air Traffic Control Services" (APS-1).

Satisfying the criteria does not necessarily entail or insure automatic establishment or discontinuance, nor does it constitute an FAA commitment. Airway Planning Standard criteria are but one of several inputs to the FAA decision-making process relative to investment in facilities and equipment. The criteria in no way affect the responsibilities of the operating services to consider all other factors pertinent to the establishment/discontinuance decision.

The criteria compare the present value of ASDE benefits with the present value of cost over a 20-year time frame, using site-specific activity forecasts, weather probabilities, and runway configurations to develop estimated benefits. The present values are then obtained by discounting the future costs and benefits to the present time at a compound rate and summing the results.

An investment meets benefit/cost criteria when the ratio of benefits to cost is 1.0 or greater. This is the same as saying that the values of benefits exceed costs. An investment fails to meet the criteria when this ratio is less than 1.0. Approximations and assumptions inherent in the analysis suggest an investment (or possibilities for discontinuance) is "too close to call" when the ratio is within 0.1 of 1--i.e., between 0.9 and 1.1. Decisions in these cases should consider factors in addition to the economic analysis outlined in this report.

Establishment Criteria: A site meets ASDE establishment criteria when the present value of benefits, BPV, equals or exceeds the present value of establishment costs, CPV. This is usually stated in ratio form: $BPV/CPV \geq 1.00$.

Discontinuance Criteria: An ASDE meets discontinuance criteria when the present value of the cost of continued operation less the cost of shutting-off the ASDE, CMPV, exceeds the present value of benefits, i.e.: $BPV/CMPV < 1.00$.

If continued ASDE operation is not economically justified, a site-specific analysis will be performed which shall include, but not be limited to:

- Evaluation of factors unique to the location;
- Operational factors otherwise not accounted for by the benefit/cost analysis;

- The possibility of significant changes in traffic activity attributable to unique local conditions.

III. ASDE COSTS

ASDE and AMASS costs can be segregated into two categories: investment capital costs (COSTE) and annual or on-going operations and maintenance costs (COSTA). The two cost categories are split as follows:

- o Investment (COSTE): The cost of facilities, equipment, and site preparation (or implementation).
- o Annual (COSTA): The cost of electricity, support, and maintenance.

ASDE costs are given in Table 3.1 through Table 3.3. AMASS costs are given in Table 3.4 and Table 3.5 and total ASDE/AMASS costs are given in Table 3.6.

A. Costs Relevant to Establishment Criteria

These establishment criteria are based on benefit/cost analysis. The only costs relevant to benefit/cost analysis are those current and future costs which could be avoided or "saved" if a decision were made not to continue with the ASDE project. These costs are referred to as "non-sunk" costs.

Costs which were incurred in the past by the Government because of the ASDE project or which will occur in the future and which the Government is committed to paying, such as a liability contingent upon cancellation of a contract, are referred to as "sunk" costs and are irrelevant to the investment decision. All production contract costs incurred to date are by definition sunk costs.

As of this report, the investment costs associated with producing the first unit of ASDE, and only those costs, are sunk costs[1]. These include costs associated with production design and design reviews, preparation of production specifications, first article production, installation, testing, and procurement of material.

It follows that the variable costs associated with production and installation of ASDE units other than the first unit are the only non-sunk ASDE investment costs. Of course, annual costs are also non-sunk costs.

All AMASS costs, both investment and annual costs, are non-sunk.

[1] Per discussions with the ASDE-3 project office on August 15, 1991.

B. ASDE Investment Costs[2]

Investment or capital costs can be segregated into hardware costs and site preparation (or implementation) costs. As identified above, the only portion of these costs relevant to the establishment criteria is the non-sunk portion of those costs. The investment cost for the first unit is *all* sunk cost.

The only relevant investment cost for this analysis is the non-sunk variable cost for units other than the first unit. The average variable cost for each unit other than the first unit is $4.0 M in Then-Year (or inflated) dollars. This consists of $2.5 M hardware cost and $1.5 M implementation cost. After adjustments to these costs to deflate them to constant base year FY 90 dollars, the variable average unit cost is $3.6 M, consisting of a hardware cost of $2.3 M and an installation cost of $1.3 M.

C. ASDE Annual Costs

The on-going O&M costs are incurred annually from the time the ASDE installation becomes operational until the time it is replaced or removed; they are estimated to total $83,850 per year in 1990 dollars. O&M costs include several components: annual ASDE maintenance costs, including parts and labor, annual ASDE operating costs, primarily utilities, and annual ASDE support, consisting of items such as configuration management and supply support. Annual maintenance costs include scheduled maintenance of 20 airway facilities hours valued at $1,300 and associated costs of parts amounting to an estimated $8,000 per year. In addition, an estimated $372 in airway facilities labor and $42,887 in parts will be necessary annually to cover unscheduled maintenance. Annual electrical costs include electricity for an average of 3,431 hours per year at 41.6 KW per hour, and an average of 6.4 cents per KW, the annual operations cost is estimated to be $9,135. Annual per unit support costs for configuration management, supply support, and training are estimated to be $22,156.

[2] Then-Year dollar investment costs identified in Paragraph B and Base-Year annual cost identified in Paragraph C have been reviewed by the ASDE-3 project office (September 15, 1992). Rates used to deflate to Base-Year dollars and to discount are official rates published by OSD and OMB respectively.

D. Total ASDE Costs Per Unit

Total relevant unit ASDE costs (CPV_{ASDE}) for a specific unit over the life of the equipment (20 years) are:

$$CPV_{ASDE} = COSTE_{ASDE} + COSTA_{ASDE}$$

where

$$COSTE_{ASDE} = ((A - B) + C) / X$$

and

$$COSTA_{ASDE} = \sum_{c=1}^{20} \frac{COSTA_{ASDE,c}}{(1.1)^{c}}$$

and where

A = Government estimate of total production contract cost
B = Government estimate of total sunk production contract cost
C = Government estimate of total implementation cost
X = Quantity of units ordered in the production contract less the first unit
c = an index starting at the first year of the operational life and ending in the last

E. Total AMASS Costs Per Unit[3]

Total relevant unit AMASS costs (CPV_{AMASS}) for a specific unit over the life of the equipment are:

$$CPV_{AMASS} = COSTE_{AMASS} + COSTA_{AMASS}$$

where the component variables are defined as in paragraph D above. AMASS costs, however, were evaluated over a 17, not a 20, year life cycle[4].

[3] Undeflated and undiscounted estimates of AMASS costs were provided by the ASDE project office on September 21, 1992.

[4] It is planned that AMASS will be installed three years after installation of the ASDE. To maintain comparability in summing the life cycle costs of ASDE and AMASS, ASDE's life cycle cost was estimated for 20 years of operation and AMASS for 17 years of operation.

AMASS investment cost ($COSTE_{AMASS}$) is $16.7 M Base-Year FY 90 discounted dollars for the first unit of AMASS and $0.6 M for each additional unit. Seventeen years of O&M costs in Base-Year FY 90 discounted dollars are $0.2 M ($COSTA_{AMASS}$) for each unit.

F. Total ASDE/AMASS Costs

Total ASDE plus AMASS costs (CPV) for a specific unit over the life of the equipment (20 years) are:

$$CPV = CPV_{ASDE} + CPV_{AMASS}$$

Table 3.1-A: ASDE Investment Costs (Then-Year Dollars)
(First of Three Pages)

(Dollars in Millions)

					Number of Units	Average Unit Cost
A.	Total Excluding Installation:[5] [6]	$203.2			33	
	(1) Sunk Cost (as of 09/30/91):[7]		$122.2			
	(a) Non-recurring:[8]			$122.2	1	$122.2
	(b) Recurring:			----	32	----
	(2) Non-Sunk Cost		$81.0			
	(a) Non-Recurring:			----	0	----
	(b) Recurring:			$81.0	32	$2.5

[5] Cost Source: ASDE-3 Major Systems Acquisition (MSA) Dry Run Briefing, 18 August 1992, Chart 16 (Requirements).

[6] Quantity Source: 33 Systems, ASDE-3 MSA, 18 August 1992, Chart 15.

[7] Sunk costs based on US Air Force factors for expenditure patterns.

[8] Expenditures through the end of FY 91 were used to fund the first unit. Source: Discussions with ASDE Project Office, August 1991.

Table 3.1-A: ASDE Investment Costs (Then-Year Dollars)
(Second of Three Pages)

(Dollars in Millions)

				Number of Units	Average Unit Cost
B. Installation:[9] [10]	$48.0			32	
(1) Sunk Cost (as of 09/30/91):		----			
(a) Non-recurring:			----	0	---
(b) Recurring:			----	0	---
(2) Non-Sunk Cost		$48.0			
(a) Non-Recurring:			----	0	----
(b) Recurring:			$48.0	32	$1.5

[9] Installation of first unit is included in the non-recurring sunk cost in para. A above.

[10] Source of unit installation cost, for other than the first unit: ASDE-3 MSA, 18 August 1992, Chart 4.

Table 3.1-A: ASDE Investment Costs (Then-Year Dollars)
(Third of Three Pages)

(Dollars in Millions)

					Number of Units	Average Unit Cost
C.	Total ASDE Cost:	$251.2				
	(1) Sunk Cost (as of 09/30/91):		$122.2			
	(a) Non-recurring:			$122.2	1	$122.2
	(b) Recurring:			----	0	----
	(2) Non-Sunk Cost		$129.0			
	(a) Non-Recurring:			----	0	----
	(b) Recurring:			$129.0	32	$4.0

Table 3.1-B: ASDE Non-Sunk Investment Costs (Then-Year Dollars)[11]

(Dollars in Millions)

				Number of Units	Average Unit Cost
A.	Non-Sunk Total Excluding Installation:	$81.0			
	(a) Non-Recurring:		----	0	----
	(b) Recurring:		$81.0	32	$2.5
B.	Non-Sunk Installation:	$48.0			
	(a) Non-Recurring:		----	0	----
	(b) Recurring:		$48.0	32	$1.5
C.	Total Non-Sunk ASDE Cost ($COSTE_{ASDE}$):	$129.0			
	(a) Non-Recurring:		----	0	----
	(b) Recurring:		$129.0	32	$4.0

[11] This table is simply a display of the non-sunk costs appearing on Table 3.1-A.

Table 3.1-C: ASDE Non-Sunk Investment Costs (Base-Year FY90 Dollars)[12]

(Dollars in Millions)

				Number of Units	Average Unit Cost
A.	Non-Sunk Total Excluding Installation:	$72.2			
	(a) Non-Recurring:		----	0	----
	(b) Recurring:		$72.2	32	$2.3
B.	Non-Sunk Installation:	$41.8			
	(a) Non-Recurring:		----	0	----
	(b) Recurring:		$41.8	32	$1.3
C.	TOTAL NON-SUNK ASDE COST ($COSTE_{ASDE}$):	$114.0			
	(a) Non-Recurring:		----	0	----
	(b) Recurring:		$114.0	32	$3.6

12 This table is simply Table 3.1-B adjusted from Then-Year Dollars to FY 1990 Base-Year Dollars.

Table 3.2: <u>ASDE Annual Costs (Base-Year FY90 Dollars)</u>

OPERATING COSTS PER YEAR (COSTA$_{ASDE,\,c}$)		
AFS labor for preventive maintenance (20 hrs/year[13] @ \$65.00 per hr[14]	\$1,300	
Parts costs for preventive maintenance-\$8,000 annually[15]	\$8,000	
Estimate of labor costs of unscheduled maintenance assuming serial breakdown every 192 hrs of operation, .32 hrs to repair, and 9.4 hrs of operation per day[15] @ \$65.00 per hr[14]	\$372	
Parts for unscheduled maintenance-\$2,400 per action[15]	\$42,887	
Electricity 3,431 hrs x 41.6 KW/hr (2) x \$0.064/KW[16]	\$9,135	
Configuration management, supply support, training[17]	\$22,156	
TOTAL ANNUAL OPERATING COSTS (COSTA$_{ASDE,\,c}$)		\$83,850

[13] ASDE Project Office.

[14] Fully loaded hourly labor rate recommended by ASM.

[15] ASDE-III contractor.

[16] "Statistical Abstract of the United States-1990," Table 965, page 572.

[17] Defense Communications Agency "Cost and Planning Factors Manual".

Table 3.3: ASDE Life Cycle (Total) Costs Per Unit

(Discounted to Mid-FY 1993[18] & Denominated in Base-Year FY90 Dollars)

UNIT NON-SUNK INVESTMENT COSTS ($COSTE_{ASDE}$)	\$3.5	
UNIT OPERATING COSTS FOR TWENTY YEAR LIFE ($COSTA_{ASDE}$)	\$0.9	
UNIT NON-SUNK LIFE CYCLE COST FOR TWENTY YEAR LIFE (CPV_{ASDE})		\$4.4

[18] ASDE-3 MSA, 18 August 1992, shows deployment of all remaining units over the period of September 1992 to August 1993.

Table 3.4-A: AMASS Investment Costs (Then-Year Dollars)[19]

(Dollars in Millions)

VALIDATION	$2.0	
RESEARCH AND DEVELOPMENT	$9.0	
FACILITIES AND EQUIPMENT (Based on 33 production systems)	$37.2	
TOTAL INVESTMENT COST (Based on 33 production systems)		$48.2

[19] Data on Tables 3.4-A and 3.4-B were provided by the ASDE Project Office, September 1992, through their cost estimation contractor.

Table 3.4-B: AMASS Life Cycle Cost (Base-Year FY90 Dollars)

A. AMASS INVESTMENT COSTS (Based on 33 production systems)		
VALIDATION	$1.8	
RESEARCH AND DEVELOPMENT	$7.4	
FACILITIES AND EQUIPMENT	$31.2	
TOTAL INVESTMENT COST		$40.4
B. AMASS OPERATING COSTS (17 years of operations)		
TOTAL OPERATING COST		$17.0
C. TOTAL AMASS LIFE CYCLE COSTS		$57.4

Table 3.5: AMASS Life Cycle (Total) Costs Per Unit (Discounted & Base-Year FY90 Dollars)

TOTAL INVESTMENT COSTS ($COSTE_{AMASS}$)	
FIRST UNIT	\$16.7
EACH ADDITIONAL UNIT	\$0.6
TOTAL OPERATING COSTS FOR SEVENTEEN YEAR LIFE ($COSTA_{AMASS}$)	
FIRST UNIT	\$0.2
EACH ADDITIONAL UNIT	\$0.2
TOTAL LIFE CYCLE COST FOR SEVENTEEN YEAR LIFE (CPV_{AMASS})	
FIRST UNIT	\$16.9
EACH ADDITIONAL UNIT	\$0.8

Table 3.6: ASDE (With AMASS) Life Cycle (Total) Costs Per Unit (Discounted & Base-Year FY90 Dollars)
(Derived from Table 3.3 and Table 3.5)

(Dollars in Millions)

TOTAL NON-SUNK INVESTMENT COSTS (COSTE)	
FIRST UNIT	$16.7
EACH ADDITIONAL UNIT	$4.1
TOTAL OPERATING COSTS FOR TWENTY YEAR ASDE LIFE (COSTA)	
FIRST UNIT	$1.1
EACH ADDITIONAL UNIT	$1.1
TOTAL NON-SUNK LIFE CYCLE COST FOR TWENTY YEAR ASDE LIFE (CPV)	
FIRST UNIT	$17.8
EACH ADDITIONAL UNIT	$5.2

IV. ASDE BENEFITS

This section explains the derivation of benefits. The benefits derived from ASDEs can be quantified in two basic categories: safety and efficiency. Safety benefits due to ASDEs are prevented collisions between aircraft or other objects when operating on the surface of the airport. Efficiency benefits result from reduced departure delays at the site where the ASDE is installed.

Additional benefits beyond these two categories may be realized by the presence of an ASDE, but are not readily quantifiable. Included in this category of not readily quantifiable benefits are the reductions in delays in taxiing between the terminal and runways during reduced light and visibility conditions, and the potential for ASDE, when it is widely implemented, to affect the capacity of the National Airport and Airway System.

A. Background

The benefit estimation process presented below has been developed to:

- Make full utilization of existing data sources;
- Recognize functional differences between classes of airport users in today's deregulated environment.

The procedures also incorporate new accident rates and current economic values used to calculate benefits, as well as improved information on the likelihood of reduced visibility conditions due to weather.

In fulfillment of Congressional direction, the benefits methodology developed below makes no distinction with respect to aircraft size. The previous aircraft size dependent user classifications are replaced by generic functional user groupings. The value of ASDE-prevented fatalities and injuries and saved passenger time is calculated based upon passengers rather than aircraft size.

Because of functional differences and availability of data required to calculate benefit/cost ratios, three generic functional categories of airport users are established:

- SCS - Scheduled commercial service;
- NCS - Non-scheduled commercial service;
- NC - Non-commercial traffic.

SCS traffic by hour of the day is available from the "Official Airline Guide" [1](OAG), while "Terminal Area Forecast" (TAF) data may be used to determine operations for non-scheduled commercial and non-commercial operations. These latter data are then projected on the diurnal pattern of operations for each airport to develop estimates of hourly operations at each facility.

ASDEs are effective in preventing collisions between aircraft operating on the airport surface. During periods of reduced light and visibility, controllers having the benefit of ASDE are better able to detect whether aircraft are moving into positions required for safe operations. In the absence of ASDE, the controllers must rely on position reports, which may be in error when an aircraft wanders onto an incorrect taxiway or active runway. The availability of ASDE may also reduce the likelihood of controller error during periods of reduced light and visibility. When controllers are unable clearly to see the ground operations at the airport, and how ground operations interact with both arriving and departing aircraft, the potential for error is greater.

Use of the ASDE can also expedite departures during periods of reduced visibility and light. The benefits can best be understood in terms of typical departure operations illustrated in Figure 2. With the ASDE, controllers are able to clear aircraft to move into position to depart, and then give clearance to depart more expeditiously. When the airport is operating with one or more runways accepting both arrivals and departures (mixed configurations) shown in the top portion of Figure 2, controllers are able to determine more quickly when an arriving aircraft has passed the runway-end; at that point, they are able to issue clearance for a departing aircraft to move from the waiting line into position on the runway for departure. Controllers are also able to see when an arriving aircraft has exited the active runway, and can, at that point, issue clearance for takeoff to the departing aircraft.

There are also efficiency benefits on departure-only runways (as shown in the bottom portion of Figure 2). Controllers are better able to determine when a departing aircraft has lifted-off the runway surface. This allows the controller to provide more expeditious clearances to the next departing aircraft.

ASDE benefits are estimated in two main categories for each user class:

- B_s: Safety benefits from reduced collisions among aircraft and between aircraft and other objects.
- B_e: Efficiency benefits from reduced aircraft delay.

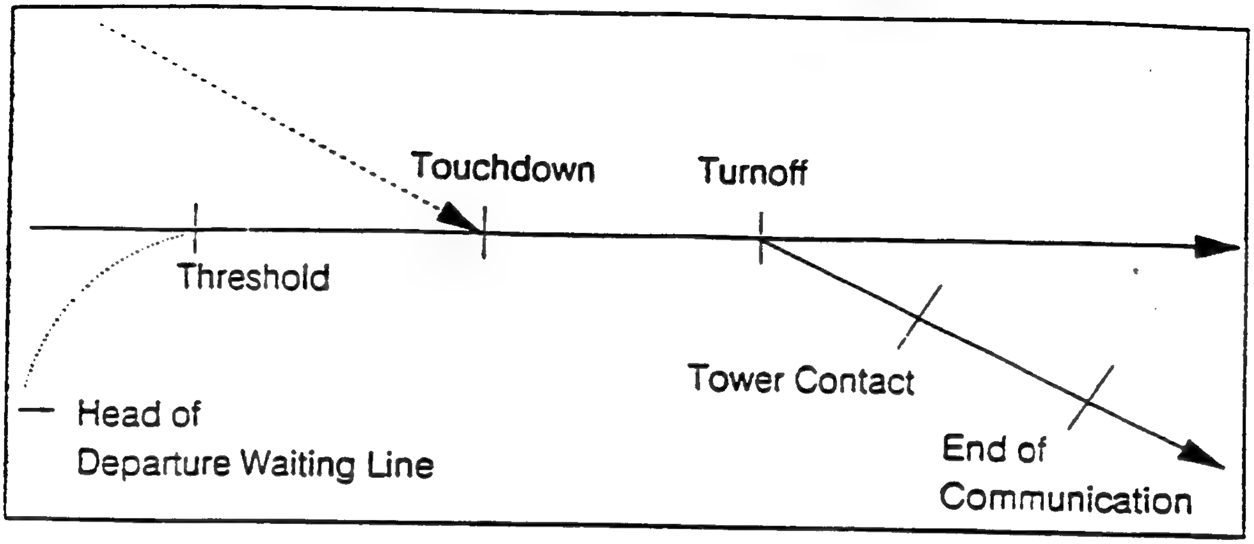
For a proposed ASDE establishment or discontinuance site, the ASDE benefits B_s and B_e for each year of a 20 year time frame are estimated based upon actual operation counts from the OAG and FAA's TAF. The details of the derivation of each of the benefits are described in the following sections.

[1] The OAGs (weekday and weekend versions) for the week of July 7, 1992, were used for weekday and weekend operations respectively.

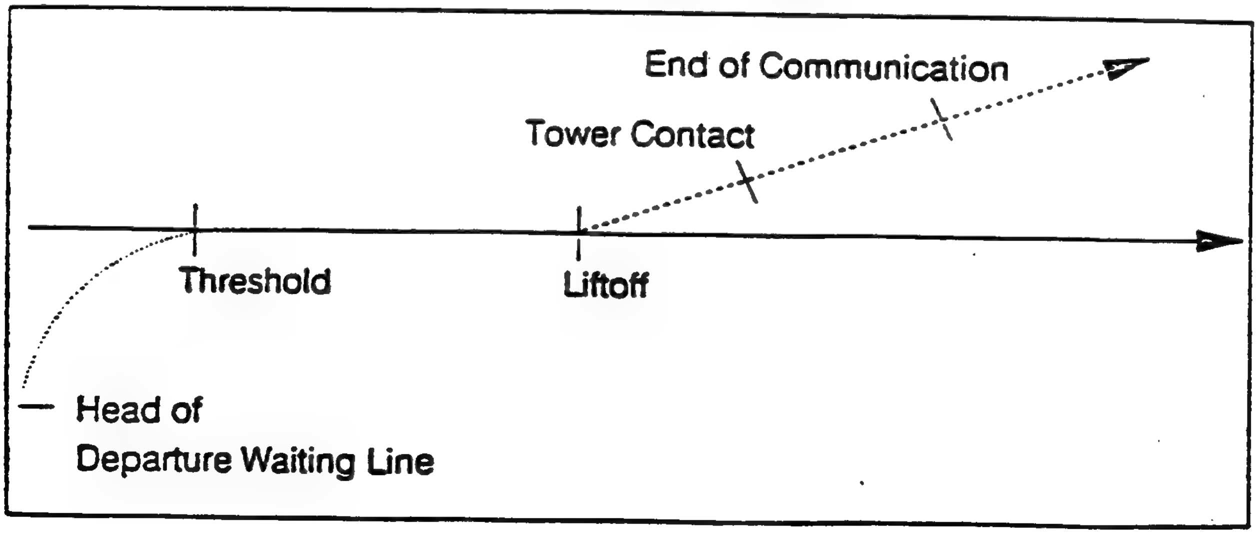
Figure 2

Departure Operations

MIXED OPERATIONS



DEPARTURES ONLY



B. Benefits from Prevented Aircraft Accidents

To assess ASDE safety benefits, data on collisions on the airport surface involving scheduled commercial aircraft in the United States were examined over the period 1971 to 1991.[2] Each accident was evaluated to determine if it was ASDE-preventable. If ASDE-preventable, it was assumed in the analysis that ASDE with the automated AMASS enhancement would be effective in enabling the tower controller to prevent all similar type accidents in the future; even if a tower controller had diverted his or her attention away from the ASDE radar display at a critical moment, the AMASS automation enhancement would detect potential trouble and alert the controller to runway incursions and potential accidents.

An accident was determined to be ASDE-preventable when it occurred in reduced visibility or light conditions, and the aircraft involved was (were):

- Operating on incorrect taxiways or runways or,
- Operating in the wrong direction on active taxiways or runways; or
- Operating according to controller instructions which were in error due to reduced visibility and light conditions; or,
- Operating on the airport surface in conflict with other aircraft or vehicles or stationary objects.

For the period 1971 through 1991, there were 11 air carrier accidents in the United States that were determined to be ASDE-preventable. These 11 accidents involved U.S. carriers and foreign airlines, but all occurred in the U.S. In these accidents, 54 people lost their lives, 34 others were seriously injured, and 134 people were less seriously injured. Eight aircraft were destroyed; nine other aircraft required substantial repairs. Total damages incurred in these ASDE-preventable accidents measured in 1990 dollars are estimated to be $221 million.

These accidents occurred in the period 1971 through 1991. During that time period, U.S. carriers performed approximately 215 million domestic operations; foreign airlines completed an estimated six million operations in the U.S. in the same time period. It is estimated that approximately 34 percent of these operations were ASDE-relevant; these are operations that took place during periods of darkness or reduced visibility. The eleven accidents divided by ASDE-relevant operations provides an estimate of the rate of accidents that could be avoided through the establishment of ASDEs. This same accident rate is applied to all user classes.

The expected number of accidents at an airport for each user class was estimated as the

[2] Records were examined from both Aviation Information Services Limited "Major Loss Record" and National Transportation Safety Board accident briefs and accident records.

product of the expected accident rate, operations, and the probability of operations during visibility conditions (k) when accidents could be prevented through the use of ASDE, or:

$$EA_i = (RC \times OPS_i \times WS_i^k)$$

where:

EA_i = expected annual accidents at an airport;

RC = accident rate for scheduled commercial services;

OPS_i = total domestic operations by U.S. aircraft and foreign operations in the U.S. for user class i

WS_i^k = percent of total operations by user i in ASDE-relevant light and visibility conditions k;

i = indexes user groups (scheduled commercial service (SCS), non-scheduled commercial service (NCS), and non-commercial traffic (NC)).

To derive the expected number of annual fatalities, serious injuries, minor injuries, aircraft destroyed, or aircraft damaged at each airport, the average incidence of such losses per accident was multiplied by the expected number of accidents.

Expected fatalities (IF_i) are defined as:

$$IF_i = (CFI_i \times EA_i)$$

where:

IF_i = expected annual fatalities at an airport for user class i;

CFI_i = average number of fatalities per accident for user class i.

Expected serious injuries (IS_i) are defined as:

$$IS_i = (CSI_i \times EA_i)$$

where:

IS_i = expected annual serious injuries at an airport for user class i;

CSI_i = average serious injuries per accident for user class i.

Expected annual minor injuries (IM_i) are defined as:

$$IM_i = (CIM_i \times EA_i)$$

where:

IM_i = expected annual minor injuries at an airport per user class i;

CIM_i = average number of minor injuries per accident for user class i.

Expected annual aircraft destroyed (AD_i) are defined as:

$$AD_i = (CDS_i \times EA_i)$$

where:

AD_i = expected annual aircraft destroyed at an airport for user class i;

CDS_i = average number of aircraft destroyed per accident for user class i.

Expected aircraft damaged (AE_i) are defined as:

$$AE_i = (CMS_i \times EA_i);$$

AE_i = expected annual aircraft damaged at an airport for user class i;

CMS_i = average number of aircraft damaged per accident.

The values for the parameters included in these equations are shown in Tables 4.1, and B-1 through B-3.

Converting Safety Benefits to Monetary Units

Economic values published by FAA and expressed in 1990 dollars were used in preparing this report. Annual estimates of the value of ASDE-preventable accidents for each airport can be derived using the following formulas:

Value of Fatalities Avoided (VFA_i) $= IF_i \times V_f$,

where V_f is the value of life.

Value of Serious Injuries Avoided (VSA_i) $= IS_i \times V_s$,

where V_s is the value of a serious injury.

Value of Minor Injuries Avoided (VMA_i) $= IM_i \times V_m$,

where V_m is the value of minor injuries.

Value of Aircraft Destruction Avoided (D_s) $= AD_i \times VDA_i$,

where D_s is the value of aircraft destroyed, and VDA_i is the cost of aircraft destroyed.

Value of Aircraft Damage Avoided (D_m) $= AE_i \times VAE_i$,

where D_m is the value of aircraft damage, and VAE_i is the cost of aircraft damaged.

The total annual safety (TAS_j) benefit for airport j summed over the i user groups is defined as:

$$TAS_j = \sum_i (VFA_{ij} + VSA_{ij} + VMA_{ij} + D_{sij} + D_{mij})$$

where i indexes user groups.

The twenty year safety benefits are defined as:

$$B_{sj} = \sum_{c=1}^{20} \frac{(TAS_{jc}) \times (1+r_{ij})^c}{(1.07)^c}$$

where c indexes years and r is an estimate of the growth in operations for user group i at airport j.

Parameters used in the ASDE safety analysis are summarized in Table 4.1. Additional details on the derivation of safety benefits are contained in Appendix B.

C. Efficiency Benefits

Many of the benefits attributable to ASDE are due to improvements in departure rates during times of poor light and low visibility. Previous studies (including the 1975 establishment criteria) and the project office indicate that ASDE's primary efficiency benefit is attributable to the aid it gives to local controllers in achieving the optimal pattern of arrivals and departures during adverse light and weather conditions. When arrivals and departures are mixed on the same runway, the ASDE effectively speeds the departure rate by reducing the amount of time the controller needs to be sure that an arriving flight either has passed the landing threshold or has exited a runway, so that a departing flight can be served before the next arrival. On a departure-only runway, the ASDE lets the controller determine that a departing aircraft has lifted-off from the runway, indicating that the runway is clear for another aircraft to move into position for takeoff.

On-site efficiency benefits depend upon three key variables:

- o D_i^k--The number of departures for each user group (i) during time of day/weather condition (k);
- o ΔW_{ij},--The expected change in service time due to the installation of ASDE;
- o DT^k_m--The percentage of time an airport operates in runway configuration m during time of day/weather condition (k).

The total time savings for user i for hour t at airport j is therefore defined as:

$$E_{ijt} = \left(\sum_k \sum_m D_i^k \times \Delta W_{ij} \times DT^k_m\right)$$

Two elements of these time savings deserve further attention. In order for the benefit estimates to be sensitive to local circumstances, airport specific estimates of departure demand are needed. These depend on not only the number of aircraft seeking to depart, but also the probable weather conditions and the user groups proportions of departures in the weather condition k. To

Table 4.1: Summary of ASDE Safety Analysis (Air Carriers Only):

Accidents per 100,000 operations	0.014
Percent of occupants killed	2.8%
Percent of occupants seriously injured	1.8%
Percent of occupants with minor injuries	6.9%
Percent of aircraft destroyed per accident	72.7%
Percent of aircraft damaged per accident	81.8%
Number of aircraft per accident	1.55
Value of life	$1,500,000
Value of serious injury	$640,000
Value of minor injury	$2,300
Economic life of ASDE (years)	20
Discount rate	7.00%

derive the number of departures by each user group during different time and weather conditions (k)--D_i^k--multiply the following three variables together:

- o V_k--The probability of visibility conditions k by time of day;
- o P_{ik}--The proportion of departures completed by user group i during condition k;
- o D_{it}--The number of departures by user group (i) and time of day (t).

The second variable deserving additional attention is the efficiency benefit. The identity for the increase in efficiency is shown below, where W_{ij} is the total time user i's aircraft spends in the system at airport j (waiting in line plus time to lift off), and q indexes whether an ASDE is present (q=2) or not (q=1).

$$\Delta W_{ij} = (W_{ij} \mid q=1 - W_{ij} \mid q=2)$$

The system times for a runway depend, in general, on five variables:

(1) The mean service time per departure when the runway handles departures only;

(2) The mean service time per arrival when the runway handles arrivals only;

(3) The mean service time per departure when the runway handles both arrivals and departures;

(4) The "arrival rates" in the queue of arriving aircraft; and

(5) The "arrival rates" in the queue of departing aircraft.

The efficiency benefits for an airport depend on how these five variables are affected by local circumstances, including:

Departure Rate Improvements Due to ASDE--Field trials at three airports--Philadelphia International, Los Angeles International and Anchorage International--were conducted between December 1989 and February 1990 to estimate the efficiency improvement due to ASDE. Measurements were taken in various weather conditions. In general, under both VFR-night and IFR conditions, the approximate reduction in processing time is estimated to be on the order of 10 to 15 seconds per departure.

Runway Configuration and Capacity--The ability of an airport to process traffic depends upon both runway configurations and capacities. The number of runways in service during particular weather conditions or conditions of light directly determines the amount of traffic that can be handled without delays. In those cases where demand exceeds capacity, queues will form resulting in delays. The potential effect of ASDE on these delays depends upon whether an ASDE can make an improvement during the light and weather conditions (see below) when the airport is operating in particular runway configurations. For example, for the same level of demand, a runway operating in the departures-only mode will process more departures than the same runway accepting both arrivals and departures; in the first case, ASDE may not have a positive benefit for a given level of demand, but it might reduce delays in the mixed runway configuration case. Data from each of the top 100 airports in the United States were used to determine the relevant runway configurations employed during different weather conditions.[3]

Tower Placement and Visibility--The need for ASDE depends upon visibility conditions at the airport, and how far controllers must see in order to operate effectively without depending on communications with aircraft. For each airport and each runway configuration, there is a minimum distance from the tower to the active runways that a controller must be able to see. Data on visibility were derived from five years of observations made by the National Oceanographic and Atmospheric Administration at the top 100 airports in the United States. When visibility conditions fall below these minimum distances between the tower and actual runways; it is assumed that ASDE equipment would be operating. These minimum distances vary significantly by airport, and depend on the placement of the tower relative to the runways, and the length of the runways.[4]

Conditions of Light--ASDE benefits are also calculated for nighttime VFR operations, and for the times of day when controllers can be affected by glare--sunrise and sunset. Data on these times of day were derived from the "World Almanac and Book of Facts".[5]

Operations Per Hour--The preceding variables determine the capacity of the airport during alternative conditions of light and visibility. The changes in delays depend upon the improvement due to ASDE, and the demand for service by hour of the day. Hourly scheduled commercial operations were available from the "Official Airline Guide" for each of the 100 airports examined. To these were added estimated hourly operations by unscheduled commercial operators, and by non-commercial

[3] These data were collected by surveying 100 tower chiefs; details on the survey are described in Appendix C.

[4] The data on tower placements were derived from "Instrument Approach Procedures" (U.S. Department of Commerce: May 4, 1989).

[5] Scripps Howard, 1989, pp. 290-301.

operators. Annual data for these later two user groups were obtained from the "Terminal Area Forecast". A diurnal pattern was projected onto these operations based upon data available from the "General Aviation Pilot and Aircraft Activity Survey" (1987).

Aircraft Operating Costs and Values of Time

In order to value the changes in delays occasioned by the operation of ASDEs, the delay savings are multiplied by FAA's published economic values for the value of time and for aircraft operating costs.

The savings in aircraft operating (SOC_{dij}) costs for user group i per day for airport j are:

$$SOC_{dij} = \sum_{t} (E_{ijt} \times VO_{ij})$$

where VO is aircraft operating costs for user i, d indexes the day of the week, i indexes user groups, t indexes the 24 hours in the day, and E_{it} is the efficiency benefit for user i in hour t. Separate values of SOC are estimated for weekdays and weekends, and are weighted approximately to develop annual time savings values.

Details of the calculation of changes in delays due to ASDE are included in Appendix A.

The savings due to passenger delay time per day ($PAXTIME_d$) depend on the number of seats ($Seats_{it}$), on-board load factors ($L.F._{it}$), and value of time VT, or, for airport j:

$$PAXTIME_{dij} = \sum_{t} (E_{ijt} \times SEATS_{ijt} \times L.F._{ijt} \times VT)$$

Annual Efficiency Benefits (AEB) for user i for airport j are then derived by summing over all weekdays and weekend days in a year:

$$AEB_{ij} = \sum_{d} (SOC_{ijd} + PAXTIME_{ijd}).$$

Annual efficiency benefits have been evaluated over the 20 year life of ASDE equipment. However, these efficiency benefits should be adjusted for projected changes in demand over time at each airport. There are readily available projections of changes in demand, but there are no similar projections for improvements in capacity at individual airports. An assumption was made that airport capacity will grow in proportion to demand for operations--i.e., that delay per operation will not increase in the future. Estimates for 1990 are assumed to grow in proportion to growth in operations (r) for user group i for each of 20 years and then the sum is discounted back to the current time using the standard, OMB-prescribed 7 percent discount rate to derive ASDE life-time efficiency benefits for airport j (B_{ej}):

$$B_{ej} = \sum_{i} \sum_{c=1}^{20} \frac{(AEB_{ij}) \times (1+r_{ij})^c}{(1.07)^c}$$

D. Establishment Criteria Benefit/Cost Ratio

The benefit/cost ratio for airport j is the ratio of the present value of benefits (BPV_j) and costs (CPV_j) at airport j:

$$BPV_j \;/\; CPV_j = (B_{sj} + B_{ej}) \;/\; CPV_j.$$

An airport should be considered for ASDE-3 equipment when the ratio exceeds one (1).

E. Discontinuance for ASDE

The ASDE-3 establishment criteria have been developed in anticipation of the equipment being installed. There are no direct field observations of the efficiency or safety effects of an operating ASDE-3.

Under certain circumstances, it may be appropriate to decommission an ASDE at an airport j. This would be the case if the ratio of the present value of benefits (BPV_j) to the present value of operating costs less the costs of shutting down ($CMPV_j$) over the remaining years of life of the equipment (c) is less than one:

$$BPV_j \;/\; CMPV_j = (BPV_{sj} + BPV_{ej}) \;/\; \sum_{c=x}^{x+20} COSTA'_c < 1$$

where $COSTA'_c$ is the present value of the annual cost of operations over the remaining life of the equipment (and x is the number of the operating year under consideration in which the ASDE will be shut down, greater than first operating year c=1) less the cost of shutting down.

V. RESULTS

The ASDE criteria were applied to 100 airports to determine the number of sites which are candidates for ASDE establishment. The benefit/cost analysis was conducted using site-specific data.

The benefit/cost analysis utilized the aviation activity forecasts from the 1992 TAF file, standard economic unit values, and costs and benefits developed in Chapters III and IV. Economic unit values include: the statistical value of life, the dollar value associated with serious injury and minor injuries, property damage values and the dollar value of passenger time. All calculations were performed in 1990 dollars.

Of the total of 100 airports considered for establishment, 35 had benefit/cost ratios equal to or greater than one, and thus would qualify for an ASDE with AMASS enhancement.

The distribution of establishment benefit/cost ratios is as follows:

Table 5.1: New Establishment Criteria Results Sorted By Benefit/Cost Ratio Ranges

B/C Range Results	No. of Airports
0.000 - .499	52
0.500 - 0.749	10
0.750 - 0.899	1
0.900 - 0.999	2
1.000 - 1.099	2
1.100 - 1.999	4
2.000 - over	29

Of those airports with benefit/cost ratios in excess of 1.0, 29 sites have benefit/cost ratios greater than 2.0; in other words, the present value of benefits from installing ASDE with AMASS enhancement would be more than double the costs over the twenty years. An additional 4 sites have benefit/cost ratios rated greater than 1.1.

Sites with benefit/cost ratios between 0.9 and 1.09 are considered "borderline" candidates. Consideration of these sites as potential establishment candidates should be based on other economic

and non-economic factors not captured in the criteria. Only four sites have a ratio between 0.90 and 1.09.

It is interesting to note that all but 2 of the 35 airports which qualify for an ASDE with AMASS enhancement qualify on efficiency benefits alone, and none qualifies on safety benefits alone.

A. Comparison With Previous Results

Because major changes have been instituted in methodology, costs, and standardized unit economic values, a comparison of results under old and new criteria was made. The results from an application of benefit/cost procedures incorporated in the 1975 criteria differed somewhat from the results derived by applying the methodology outlined in the new criteria. The summary of results is presented in Table 5.2 for 46 airports tested in both studies:

Table 5.2: Comparison of Old and New Benefit/Cost Results
(For 46 Airports Common to Both Studies)

Ratio Classes	Old	New
0.000 - .4999	16	11
0.500 - 0.749	10	6
0.750 - 0.899	2	1
0.900 - 0.999	4	0
1.000 - 1.099	1	1
1.100 - 1.999	9	4
2.000 - over	4	23

When comparing the figures in Table 5.2, it is important to note that unlike the old results, the new criteria reflect present operating circumstances, including the effects of hubs on delays, and the value of safety benefits and lost passenger time. Additionally, the new criteria reflect the cost of an ASDE with AMASS enhancement, whereas the old criteria were developed before AMASS was conceived. All of the sites that qualified in the 1975 criteria also qualify in the revised criteria.

B. Projections into the Future

The ASDE Benefit/Cost models were run from the perspective of the year 2000 to assess how many additional candidate airports (if any) would qualify.

These runs assume 1990 costs, but project activity and enplanements from a base starting in the year 2000. The results are summarized in Table 5.3 which shows that 40 airports would qualify based on a projection from the year 2000, as compared with the 33 shown in Table 5.1.

Table 5.3: Comparison of Current and Year 2000 Benefit/Cost Results

Ratio Classes	Current	2000
0.000 - 0.499	52	44
0.500 - 0.749	10	11
0.750 - 0.899	1	6
0.900 - 0.999	2	1
1.000 - 1.099	2	1
1.100 - 1.999	4	6
2.000 - over	29	31

The addition of ASDEs, beyond those currently programmed, should consider the airport configuration complexity, the number of runway incursions, and the potential productivity improvements which may be realized if the ASDE/AMASS is changed from a controller aid to a certified system for separation of traffic. Since runway incursion data have only been collected since 1988, there is an insufficient database to demonstrate a statistical correlation between runway incursions and accidents; additional studies and data collection will be required to establish appropriate relationships based solely on safety considerations.

APPENDIX A: ASDE EFFICIENCY MODEL

This appendix provides a technical discussion of the model used to estimate the efficiency benefits attributable to the installation of an ASDE at a particular airport. Central to the efficiency model is an application of queuing theory. During busy periods of the day, both arrivals and departures queue-up to be served on a limited number of runways. During conditions of poor visibility or darkness, the presence of an ASDE will reduce the queues for departing aircraft by helping controllers "see" the activity on the runway surface. In the absence of ASDE, controllers must rely on position reports made by pilots and by operators of other vehicles which consume more controller time, and thereby slow the processing of departing aircraft.

Airport operations have been modeled as a non-preemptive priority queue. This means that arrivals are always given priority in the queue; an aircraft on final approach will be given precedence over any departing aircraft with which it could potentially come into conflict. However, once a departing aircraft has reached the front of the queue, its servicing cannot be preempted by any other event. An aircraft cleared for takeoff, completes its takeoff in the model, and then the next aircraft (whether departure or arrival) is served.

The queuing model applied here is based upon a derivation developed by Thomas L. Saaty: Elements of Queuing Theory With Applications (Dover Publications, New York, NY: 1961) pps. 232-234.

Technical Discussion

An airport's runway configuration can be specified by the number of runways available to handle each of three types of aircraft operation that will be permitted on a runway: arrivals-only, departures-only and both arrivals and departures. Let

RA = number of runways handling arrivals-only during a one hour period

RD = number of runways handling departures-only during a one hour period

RM = number of runways handling arrivals and departures during a one hour period

Then, following the same conventions used for runway configurations, let

TOTA = total number of arrivals in a one hour period

TOTD = total number of departures in a one hour period

NA = number of arrivals during a one hour period assigned to each arrival runway

ND = number of departures during a one hour period assigned to each departure-only runway

NM = number of departures during a one hour period assigned to each mixed operation runway.

It is assumed that arriving aircraft have priority over departing aircraft on mixed runways and that aircraft are assigned to mixed and arrival-only runways in proportion to the number of each type of runway available:

$$NA = TOTA / (RM + RA).$$

This assumption recognizes that arriving aircraft always have priority in an active queue; if an aircraft is on final approach, it has priority over all departures in which it is in potential conflict on the airport surface.

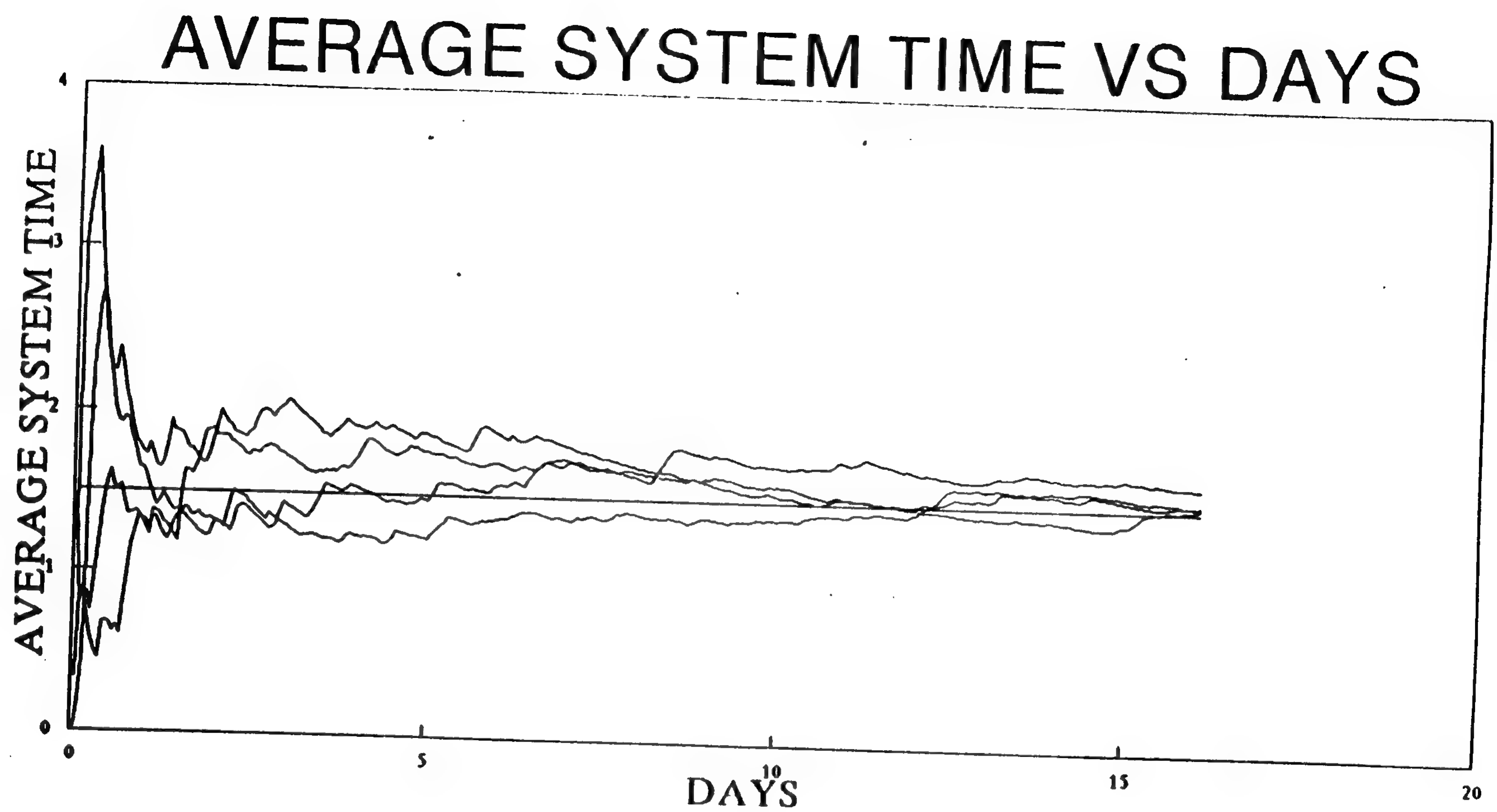
Under these conditions the optimal allocation of hourly departures (TOTD) to the RM mixed runways and RD departure-only runways occurs when waiting times are minimized. Waiting times are minimized when either the expected waiting time of aircraft departing on mixed runways is the same as the waiting time of aircraft assigned to departure-only runways or when an allocation is made of all departures to departure-only runways.

A runway is treated as a facility for processing arriving and/or departing aircraft. It is assumed that the rates at which arriving and departing aircraft enter the facility for processing can be adequately approximated by Poisson distributions and that the processing times are exponentially distributed. This assumption closely corresponds to reality. During busy hours, when most ASDE-preventable delays occur, the probability of any particular aircraft departing in a small time increment is constant and an independent event. While this situation would appear to be violated when hubbing airlines schedule a large number of departures during a 15 minute time period, the actual departure times of these flights are likely to be independently distributed.

To illustrate that the model provides accurate estimates of the mean time aircraft spend in the system (time waiting to use the runway plus time spent using the runway), a simulation was developed. Consider the case of a departure-only runway with 20 departures scheduled in a specific one-hour interval for each day of the year, and assume that the average runway occupancy time for aircraft is one minute. In this case, the arrival rate is $\lambda = 20/60 = 1/3$ arrivals per minute and the service rate is $\mu = 1$ per minute. The model estimated, therefore, that the mean time an aircraft spends in the system is $1/(\mu - \lambda) = 1.5$ minutes.

Figure A-1 shows the average system time calculated from a simulation of the activity in the one hour period replicated over 15 days. It shows that the model provides good estimates (over a 15 day period) of the time an aircraft spends on average in the system during the one hour period. The queuing model employed in the ASDE efficiency analysis should provide good estimates of service times, and therefore delays.

Figure A.1



AVERAGE SYSTEM TIME VS DAYS
AVERAGE SYSTEM TIME
0
1
2
3
4
DAYS
0
5
10
15
20

Waiting Time Model

Following the convention used for runway configurations, let

TA = mean processing time for arriving aircraft of a given type under specified meteorological conditions

TD = mean processing time for aircraft departing on a departure-only runway

TM = mean processing time for aircraft departing on a mixed use runway

WD = average time a departing aircraft spends in line waiting for access to a departure-only runway

WM = average time a departing aircraft spends in line waiting for access to a mixed-use runway.

Then, waiting time is

$$WM = (NA^*TA^2 + NM^*TM^2) / ((1 - NA^*TA)(1 - NA^*TA - NM^*TM))$$

on mixed use runways and

$$WD = (ND^*TD^2) / (1 - ND^*TD)$$

on departure-only runways.

Let W0 (t,k,m) and W1 (t,k,m) be the average waiting times experienced by aircraft departing during hour t under meteorological conditions k [1] on runway combination m, when the processing times are those associated without and with ASDE respectively. The time benefit conferred by ASDE under these conditions is

$$\Delta W(t,k,m) = W0(t,k,m) - W1(t,k,m).$$

Let p (t,k) be the probability of meteorological conditions k in hour t, with k = 1 denoting VFR conditions at night or during the hour following sunrise or the hour preceding sunset, k =2 denoting Category 1 visibility conditions and k = 3 denoting Category 2 or worse visibility conditions.

---

[1] Note that in Chapter IV of this study, k indexes both time (t) and weather conditions; here the two are separated to aid in the exposition of concepts.

Let q (t,m (k)) be the probability of utilizing runway combination m during hour t under condition k. At present, it is assumed that runway utilization is independent of time of day, so that q (t,m (k)) can be represented by q (m (k)).

The average benefit $\Delta W\ (t,k)$ conferred on an aircraft departing in hour t under conditions k is given by

$$\Delta W\ (t,k) = \sum_{m=1}^{m(k)} \Delta W\ (t,k,m)\ q\ (t,m\ (k))$$

Let d (i,t) be the number of aircraft of type i departing in hour t where i = 1,2,3 respectively denote scheduled commercial, non-scheduled commercial, and non-commercial aircraft.

The time savings realized by aircraft of type i in hour t is $\Delta W\ (t,k)\ d\ (i,t)$ and the total time savings realized by aircraft of type i in hour t is

$$E\ (i,t) = \sum_{k=1}^{3} \Delta W\ (t,k)\ p\ (t,k)\ d\ (t,a).$$

APPENDIX B: ASDE SAFETY ANALYSIS

This appendix provides additional details on the safety analysis conducted in the development of establishment criteria for ASDE. It was generally recognized that the types of accidents that could be prevented by ASDE were likely to be relatively rare.

- ASDEs would be installed at a relatively small subset of airports in the United States; the large capital expense for an ASDE system would preclude its installation at smaller airports.

- Activity at most large commercial airports is dominated by scheduled commercial service: these types of operations lead to a very small number of accidents to begin with, and only a small subset of accidents would likely be prevented by ASDE.

- The types of accidents likely to be prevented by ASDE would occur on or near the surface of the airport, and would most likely involve collisions between two aircraft on the same active runway or taxiway, or collisions between aircraft and other obstacles or vehicles on the runway surface.

In order to examine the potential for ASDEs to prevent future aircraft accidents, a review was made of the past accident records and to determine which of the past accidents could feasibly have been avoided if an operating ASDE had been present. It was recognized that sufficient details on the accidents themselves would only be available for commercial operations. Most accidents involving non-commercial operations do not receive the same level of investigative attention as commercial accidents. For this reason, the accident-prevention-capability of ASDE was based solely on the experience of commercial operators. The expected rate of ASDE-preventable accidents for commercial operations were projected onto all other types of operations including non-scheduled commercial operations, and non-commercial operations.

Review of Accident Information

The operating life of ASDE equipment is projected to be approximately 20 years. Data on accidents were, therefore, reviewed for the same length of time, covering the period 1971 through 1991. Two sources of accident information were employed:

- National Transportation Safety Board Accident Reports and Briefs;

- "Major Loss Record," published by Aviation Information Services, Ltd.

Results

Accidents included in the evaluation were those involving commercial airlines (both domestic and foreign carriers) in the United States. Eleven airline accidents were identified as being ASDE-preventable over the period 1971-1991. The property damage and other related details are shown in Table B-1.

Of the eleven accidents, six involved collisions between aircraft. The remaining accidents involved only one aircraft. Two of these involved collisions with airport vehicles (snow sweeper or truck) on active runways. All of the accidents took place during poor visibility conditions.

Table B-1 also provides estimates of the aggregate property damage incurred as well as the per-accident average property damage in various categories. The typical ASDE-preventable accident involved:

- o 1.55 aircraft; on-average, 0.73 aircraft were destroyed in each accident;
- o $9.7 million in losses due to destroyed or damaged aircraft;
- o $28,200 in damage to airport vehicles.

Table B-2 summarizes the fatalities and injuries that occurred in the ASDE-preventable accidents. In the 11 accidents identified:

- o 54 people were killed;
- o 34 people were seriously injured;
- o 134 people experienced minor injuries.

The aggregate value of these human losses was $103 million, or $9.4 million per accident.

Accident Model

The following hypothesis is central to the ASDE safety model:

- o Because ASDE accidents are relatively rare, the best estimates of the potential effects of ASDE on aviation safety is the product of ASDE relevant operations at a specific airport multiplied by the ASDE-preventable accident rate over a 20 year period.

This results in an ASDE-preventable accident rate equal to 0.014 accidents per 100,000 operations.

For air carriers, the average costs of ASDE-preventable accidents reported in Tables B-1 and B-2 are applied to the product of the accident rate and local airport operations. For other types of aircraft operations, loss rates more suitable to the accidents experienced for those types of operations are applied. The latter are reported in Table B-3. These figures are based upon an extensive analysis of the accidents experienced by non-scheduled commercial and non-commercial operators as reported in: "Establishment and Discontinuance Criteria for Airport Traffic Control Towers," (August, 1990).

TABLE B.1
PROPERTY DAMAGE
ASDE PREVENTABLE ACCIDENTS IN U.S.
DOMESTIC AND FOREIGN CARRIERS

DATE	AIRLINE	AIRPORT	AIRCRAFT INVOLVED	AIRCRAFT DESTROYED	TYPE DESTROYED	AIRCRAFT VALUE (1990)	A/C MAJOR DAMAGE	TYPE DAMAGE	DAMAGE VALUE (1990)	ANCILLARY COSTS	EXPLANATION
1 810218	AIR CALIFORNIA	JOHN WAYNE	1	1	NARROW TWIN B737-293	$12,800,000	0				
2 800902	AVIANCA	MIAMI	1	0			1	4 ENG WIDE B747-259B	$3,015,000		
3 721220	REPUBLIC	O'HARE	2	1	NARROW TWIN DC9-31	$12,800,000	0				
	DELTA	O'HARE		0			1	COMM PROP CV880-22-2	$ 221,000		
4 790215	FLYING TIGER	O'HARE	1	0			1	4 ENG WIDE B747-132F	$3,015,000		
5 831219	JAL	ANCHORAGE	1	0			1	4 ENG WIDE B747-246F	$3,015,000	$60,000	TRUCK
6 831223	KOREAN	ANCHORAGE	2	1	4 ENG WIDE DC10-30CF	$26,500,000	0				
	SOUTH CENTRAL	ANCHORAGE		0			1	PIPER NAVAHO PA-31-350	$14,680		
7 870820	AIRBORNE	STEWART	2	0			1	4 ENG NARROW DC8	$1,380,000		
	OTHER	STEWART		0			1	TWIN NARROW DC9-31	$1,453,000		
8 831220	OZARK	SIOUX FALLS	1	1	NARROW TWIN DC9-31	$12,800,000	0			$250,000	SNOW SWEEPER
9 900118	EASTERN	ATLANTA	2	0			1	3 ENG NARROW B727-225	$384,000		
	EPPS AIR	ATLANTA		1	TYPE III GA KING AIR 100	$81,156	0				
10 911203	NORTHWEST	DETROIT	2	1	NARROW TWIN DC9-14	$12,800,000	0				
	NORTHWEST	DETROIT		0			1	3 ENG NARROW B727-251	$1,664,000		
11 910201	USAIR	LOS ANGELES	2	1	NARROW TWIN B737-3B7	$12,800,000	0				
	SKY WEST	LOS ANGELES		1	METRO III	$2,284,800	0				
	TOTAL		17	8		$92,865,956	9		$14,161,680	$310,000	
	PER ACCIDENT		1.55	0.73		$8,442,360	0.82		$1,287,425	$28,182	
	PERCENT			47.1%			52.9%				

TABLE B.2
FATALITIES AND INJURIES
ASDE PREVENTABLE ACCIDENTS IN U.S.
DOMESTIC AND FOREIGN CARRIERS

DATE	AIRLINE	AIRPORT	TOTAL PASSENGERS	FATALITIES	SERIOUS INJURIES	MINOR INJURIES	ACCIDENT INVESTIGATION
1 810218	AIR CALIFORNIA	JOHN WAYNE	75	0	4	0	$1,000,000
2 800902	AVIANCA	MIAMI	234	0	0	0	$1,000,000
3 721220	REPUBLIC	O'HARE	139	10	9	119	$1,000,000
	DELTA	O'HARE	97	0	0	0	
4 790215	FLYING TIGER	O'HARE	234	0	0	0	$1,000,000
5 831219	JAL	ANCHORAGE	234	0	0	0	$1,000,000
6 831223	KOREAN	ANCHORAGE	236	0	0	0	$1,000,000
	SOUTH CENTRAL	ANCHORAGE	8	0	0	0	
7 870820	AIRBORNE	STEWART	110	0	0	0	$1,000,000
	OTHER	STEWART	75	0	0	0	
8 831220	OZARK	SIOUX FALLS	75	1	0	2	$1,000,000
9 900118	EASTERN	ATLANTA	101	0	0	0	$1,000,000
	EPPS AIR	ATLANTA	9	1	0	0	
10 911203	NORTHWEST	DETROIT	90	0	0	0	$1,000,000
	NORTHWEST	DETROIT	101	8	21	13	
11 910201	USAIR	LOS ANGELES	103	22	0	0	$1,000,000
	SKY WEST	LOS ANGELES	13	12	0	0	
	TOTAL		1934	54	34	134	
	PER ACCIDENT		175.82	4.91	3.09	12.18	$1,000,000
	TOTAL COST			$81,000,000	$21,760,000	$308,200	$11,000,000
	PERCENT			2.8%	1.8%	6.9%	

TABLE B.3

ASDE PREVENTABLE ACCIDENTS

DERIVATION OF PERCENTS INJURED AND DAMAGED FOR NONSCHEDULED COMMERCIAL AND NONCOMMERCIAL

TYPE ACCIDENT	ACCIDENT RATE	COLLISION AIRCRAFT	NONSCHEDULED COMMERCIAL FRACTIONS					NONCOMMERCIAL FRACTIONS				
			FATAL	SERIOUS	MINOR	DESTROYED	DAMAGED	FATAL	SERIOUS	MINOR	DESTROYED	DAMAGED
ONE AIRBORNE	1.238	2	0.000	0.025	0.150	0.154	0.654	0.000	0.025	0.150	0.154	0.654
BOTH ON GROUND	2.775	2	0.024	0.028	0.071	0.136	0.700	0.024	0.028	0.071	0.136	0.700
OTHER	1.185	1	0.004	0.015	0.090	0.039	0.922	0.013	0.033	0.103	0.062	0.930
WEIGHTED AVERAGE			0.01498	0.02552	0.09468	0.12836	0.71620	0.01613	0.02784	0.09635	0.13132	0.71722

SOURCE: DEC 1988 TOWER CRITERIA PAGES 18, 20 FOR ONE AIRBORND AND BOTH ON GROUND AND PAGES 23 AND 25 FOR OTHER.

APPENDIX C

TOWER CHIEF SURVEY

ASDE efficiency benefits depend importantly upon the number of aircraft and the visibility conditions during a specified period of time. When visibility is poor, or when it is dark, and there are a substantial number of aircraft departures relative to airport capacity, the presence of an ASDE is likely to reduce delays experienced by aircraft operators. Two important pieces of information are required to characterize these conditions:

- o The number of runways available for departures and arrivals during different types of weather/visibility conditions;
- o The decline in the number of aircraft operations due to poor weather conditions.

Both types of information are necessarily airport-specific. The number of runways available will always depend upon the configuration of the airport itself, and especially on the distance between parallel runways. In addition, the number of aircraft operations during different types of weather depends importantly upon the composition of those operations. For example, scheduled commercial operations are generally less affected by adverse weather conditions than are other operators.

Information on runway configurations in use and aircraft operations during adverse weather conditions is not generally available. In order to overcome this problem, a survey of tower chiefs at the largest 100 airports in the United States was conducted during the month of March, 1990. With the cooperation of ATR-120, a 100 percent response rate to the enclosed survey form was realized.

Data collected from this survey were used to characterize:

- o Airport capacity during specific weather conditions by type of runway--mixed, departures-only, arrivals-only;
- o Number of operations during specific weather conditions.

ASDE Tower Survey

Airport ______________________

Respondent ______________________

Telephone ______________________

1. For each weather condition, please indicate the TYPICAL runways actually operating, and the approximate percentage of time you operate in each configuration.

EXAMPLE:

About 70% of the time in night VFR, the airport operates runway 17 with arrivals and departures, and runway 27R for arrivals only, and 27L for departures only.

About 20% of the time in Night VFR, the airport operates both arrivals and departures on runway 17, and arrivals on 27R and 27L.

About 10% of the time in Night VFR the airport operates arrivals on 27R and departures on 27L.

Night VFR

Config. Number	Arrival Runway(s)	Departure Runway(s)	Percent of Time
1	17, 27R	17, 27L	70%
2	17, 27R, 27L	17	20%
3	27R	27L	10%
4			%
5			%
6			%
			100%

YOUR RESPONSES BEGIN OVERLEAF

Return to: F. Berardino
Gellman Research Associates
115 West Avenue
Jenkintown, PA 19046

Night VFR

Config. Number	Arrival Runway(s)	Departure Runway(s)	Percent of Time
1			%
2			%
3			%
4			%
5			%
6			%
7			%
8			%
			100%

Day or Night CAT I: Runways in Use

Config. Number	Arrival Runway(s)	Departure Runway(s)	Percent of Time
1			%
2			%
3			%
4			%
5			%
6			%
			100%

Day or Night CAT II: Runways in Use

Config. Number	Arrival Runway(s)	Departure Runway(s)	Percent of Time
1			%
2			%
3			%
4			%
			100%

Day or Night CAT III: Runways in Use

Config. Number	Arrival Runway(s)	Departure Runway(s)	Percent of Time
1			%
2			%
3			%
4			%
			100%

2. During IMC, some user groups reduce their operations relative to level of operations during VFR conditions. Please provide your best estimate of the percentage REDUCTION in operations for each user group during the weather conditions indicated.

EXAMPLE

CAT III

User Group	% Reduction
Jet Carriers	80%
Commuters	100%
GA	100%
Military	100%

80% of Jet Carrier flights that would operate during VFR will not operate during CAT III conditions.

100% (all) commuter, GA, and military flights that would operate during VFR will not operate during CAT III conditions.

YOUR RESPONSES:

CAT I

User Group	% Reduction
Jet Carriers	%
Commuters	%
GA	%
Military	%

CAT II

User Group	% Reduction
Jet Carriers	%
Commuters	%
GA	%
Military	%

CAT III

User Group	% Reduction
Jet Carriers	%
Commuters	%
GA	%
Military	%

REFERENCES

ASDE-3 – Airport Surface Detection Equipment; Contract DTFA01-85-C-00054. Melville, NY: United Technologies, Norden Systems, 1989.

Aviation Information Services Ltd. Major Loss Record - Volume 1 - Chronological & by Aircraft Type. London, nd.

Baran, G. et al. Airport Surface Traffic Control Systems Deployment Analysis. McLean, VA: Mitre Corporation, September 1973. (Prepared for U.S. Department of Transportation)

Bellantoni, John and Ralph Kodis, eds. An Analysis of Runway-Taxiway Transgressions at Controlled Airports. Washington, DC: Federal Aviation Administration, April 1981.

Benscher, D. DPU User Interface Software Design. Melville, NY: Norden Systems, nd.

Billings, Charles E. and E. S. Cheaney, eds. Information Transfer Problems in the Aviation System. Washington, DC: National Aeronautics and Space Administration, 1981. (NASA Technical Paper 1875)

Billings, Charles E. and Dolores B. O'Hara. Human Factors Associated With Runway Incursions. NASA, Ames Research Center, October 1978. (NASA Technical Memorandum 78540)

Department of Commerce. Bureau of the Census. Statistical Abstract of the United States: 1990. 110th ed. Washington, DC, 1990.

Department of Commerce. National Ocean Service. Instrument Approach Procedures. May 4, 1989, 15 vols.

Federal Aviation Administration. ASDE-3 Development - Project Plan. Atlantic City Airport, NJ, March 1985.

-----. Economic Analysis of Investment and Regulatory Decisions-A Guide. Washington, DC, January 1982. (FAA-APO-82-1)

-----. Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs. Washington, DC, 1990. (FAA-APO-90-10)

-----. Engineering and Development Program Plan - Airport Surface Traffic Control. Washington, DC, July 1972. (FAA-ED-08-1)

-----. Establishment Criteria for ASDE-3 (Airport Surface Detection Equipment). Washington, DC, December 1975. (FAA-ASP-75-3)

-----. General Aviation Pilot and Aircraft Activity Survey. Washington, DC, September 1985. (FAA-MS-85-1)

-----. Order 7031.2C - Airway Planning Standard Number One - Terminal Air Navigation Facilities and Air Traffic Control Services. Washington, DC, November 1984.

—. Terminal Area Forecasts, FY 1989-2005. Washington, DC, April 1989.

Hollister, Walter M. Airport Surface Traffic Automation Study. Lexington, MA: Lincoln Laboratory, MIT, May 1988. (Prepared for Federal Aviation Administration, DOT/FAA/PS-87/1)

Kinney, Glenn C. The Human Element in Air Traffic Control: Observations and Analyses of the Performance of Controllers and Supervisors in Providing ATC Separation Services. McLean, VA, Mitre Corporation, December 1977. (Prepared for Federal Aviation Administration)

Moses, Harry C. Engineering and Development Program Plan - Air Traffic Control Surveillance Radar. Washington, DC, Federal Aviation Administration, December 1972. (FAA-ED-02-1)

National Transportation Safety Board. Aircraft Accident Reports. Washington, DC, various years.

—. Annual review of Aircraft Accident Data - U.S. General Aviation. Washington, DC, various years.

Official Airline Guide - North American Edition. March 20 and 24, 1990.

Rempfer, Paul S. et al. Airport Surface Traffic Control System Requirements Analysis. Washington, DC: Federal Aviation Administration, May 1979. (FAA-EM-79-5)

World Almanac and Book of Facts. New York: Scripps Howard, 1989.